# A New IEC Standard on the Measurement of Power Quality Parameters

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**Significance**
Part 2 – Development of standards – Reality Checks
Part 5 – Monitoring instruments

A progress report on the development of an IEC standard describing the background of the difficulties created by non-standard definitions and algorithms for power quality disturbances and presenting the approach recommended by the appointed IEC Working Group.

At the time this paper was presented, consensus had not yet been reached, and the final document is scheduled by IEC for publication in mid-2003.

# A NEW IEC STANDARD ON THE MEASUREMENT OF POWER QUALITY PARAMETERS

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**Abstract** - Following an initiative from the French and the U.S. National Committees, the IEC Technical Committee TC77 charged its Subcommittee 77A (Low-Frequency Phenomena) with the development of a new standard on the measurement of power quality parameters. The objectives of this standard, as stated in its scope, are to facilitate - and hopefully ensure - obtaining reliable, repeatable, and comparable results of power quality parameters, regardless of the compliant instrument being used and regardless of its environmental conditions. The purpose of this paper is to broaden the consensus-building process, beyond the closely-knit TC77 community, toward greater acceptance when the project reaches the final draft voting status.

## I. BACKGROUND AND EXPECTED BENEFITS

The pioneering development of portable power quality monitors, with built-in graphics capability, in the mid-1980s triggered intense interest among equipment users concerned with disruption of their operations allegedly caused by poor quality of their electric power supply. Concurrently, increasing dependency on sophisticated electronic controls made the issue even more pressing. The availability of these graphic reports, which became known as "signatures" spurred a new awareness of power quality issues [1]. This interest opened the market to other instrument manufacturers, each developing their own algorithms and software for the measurements of a variety of disturbances, not necessarily based on common (shared) definitions of these disturbances [2], [3], [4].

As a consequence of these independent developments, the resulting survey data have been generally difficult, if not impossible, to compare between two surveys conducted with different instruments. During the initial phases of a new technology development, open competition will generally be a strong and welcome factor to promote innovation, but the result can also become chaotic and counter-productive. A first attempt toward bringing compatibility in this new field was made by the Institute of Electrical and Electronics Engineers (IEEE) in 1987, chartering a working group for the development of a Recommended Practice, which culminated in 1995 with the publication of IEEE Std. 1159 [5].

## II. WHAT IS POWER QUALITY ?

Asking this question in the year 2000, and after all the work and papers published since the term was first used [6] might seem awkward. However, a brief review of what diverse individuals and organizations mean by "Power Quality" will provide some perspective on the underlying issues, and will show how useful the new IEC standard will be to bring about a shared understanding.

In a landmark 1996 decision, the Committee of Action of the IEC approved a recommendation to undertake work on power quality issues as part of the scope of Technical Committee TC77 on Electromagnetic Compatibility (EMC). This decision, recommended by an Ad Hoc Group composed of power quality experts from ten countries, marks an expansion of the scope that will then reach beyond the purely technical issues generally addressed by the EMC community.

The IEC Ad Hoc Group considered in 1996 three areas of contributions which an IEC Power Quality Group could make, complementing the work currently done by existing working groups or project teams of TC77:

- Bringing order to the present chaos of uncoordinated methods of monitoring power quality.
- Proposing a classification of power quality levels describing what end-users can expect.
- Building bridges among producers and users of electric power, and equipment manufacturers.

Concerns surfaced that undertaking such work might ultimately result in the development and imposition of standards on the quality of "electricity as a product" and create an adversarial relationship. Fortunately, these concerns seem to have receded and a new working group was chartered in 1997 with the specific scope of defining measurement methods "for obtaining reliable, repeatable, and comparable results regardless of the compliant instrument being used and regardless of its environmental conditions."

The first Committee Draft (CD) of the IEC document has been circulated in 1999 [7] and resulted in 230 comments from the National Committees. With the concurrence of the IEC Working Group, this paper presents a progress report, identifying major topics and unresolved issues.

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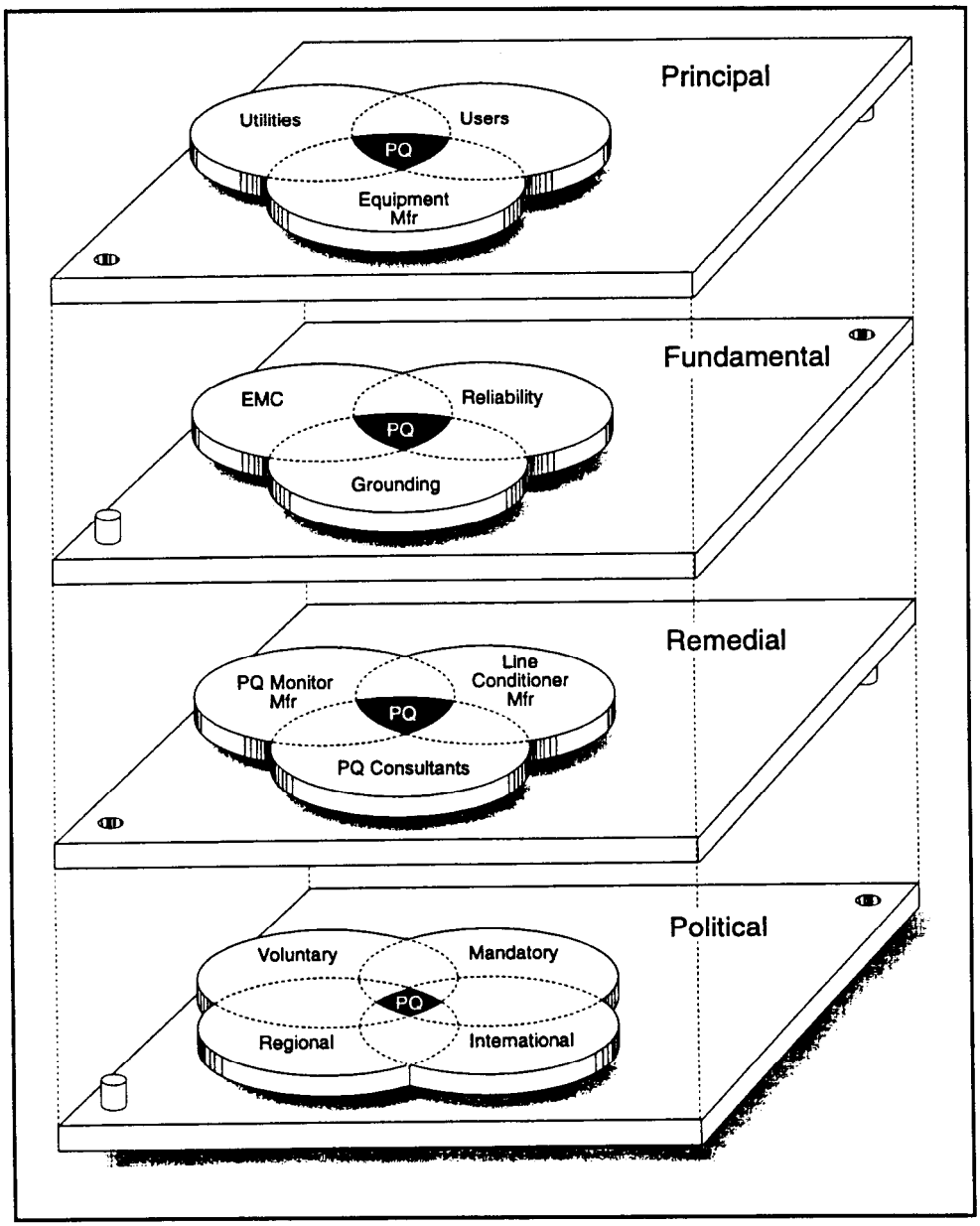
Power quality and EMC share many concerns, to the point that each has at some time been described as being a subset of the other. In addition to this fundamental technical aspect, other issues permeate any discussion of power quality. It would be more accurate to draw a multi-dimension diagram with many overlaps. Also involved are the principals in the transactions, remedial actions, and political implications (see Figure 1).

As further illustration of the different perceptions of the power quality concept, Table 1 shows a collection of definitions developed by various standards-writing groups and industry publications. Another illustration of the diversity is Table 2 which shows the terms used in French-speaking countries, in their own national version of French (French being one of the official languages of the IEC) with a literal translation into English.




Power quality issues involve overlapping stakeholders' interests or technical aspects in many domains. In this figure, four domains are represented as planes in an exploded view, showing how for each domain, developing a Power Quality (PQ) document will involve overlapping topics and draw upon the interests and expertise of the stakeholders. A successful development will integrate all topics in each domain, and consolidate all domains into one entity. (Note how the artist has provided registration pegs on the planes so that the re-assembly will be a good fit!)

**Figure 1 - The many dimensions of power quality issues**

**Table 1 — Evolution of the concept of Power Quality**

| DATE | SOURCE | DEFINITION - Explicit or Implicit |
|---|---|---|
| 1979 | Key "Diagnosing Power-Quality Related Computer Problems" [6] | "In summary, the answer to 'the power quality question' will be found only through a study of power line disturbances. This study is the first step towards an accurate diagnosis of computer power problems." |
| 1985 | Clemmensen and Ferraro, "The Emerging Problem of Electric Power Quality" [8] | Converse of "Dirty Power", the term often used in the early eighties to describe a power line where disturbances occur. Thus, power quality is the absence of disturbances. |
| 1986 | EPRI Internal papers | **power quality:** applies to the power coming from the electric utility supply side. |
| 1988 | PCIM Magazine [9] | "quality power is the level it takes to satisfy my customers needs." |
| 1992 | IEEE Std 1100-1992 IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment | **power quality:** The concept of powering and grounding sensitive electronic equipment in a manner that is suitable to the operation of that equipment. |
| 1995 | IEEE Std 1159-1995 IEEE Recommended Practice for Monitoring Electrical Power Quality | **power quality:** The concept of powering and grounding sensitive electronic equipment in a manner that is suitable to the operation of that equipment.<br>NOTE — Within the industry, alternate definitions or interpretations of power quality have been used, reflecting different points of view. Therefore, this definition might not be exclusive, pending development of a broader consensus. |
| 1995 | IEEE Std 1250-1995 IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances | Power Quality is a broadly used term that has been applied to voltage, service availability, and even harmonic content. Except for Clause 1, the guide has purposely avoided the use of this term. |
| 1995 | Eskom Handbook on Quality of Supply | **power quality:** Quality of supply as it affects the delivery of power and therefore includes elements of voltage quality and measurement of the availability or continuity of supply. |
| 1996 | Report from Advisory Committee on Electromagnetic Compatibility to IEC Committee of Action, 1996. | **power quality:** Set of parameters defining the properties of the power supply as delivered to the user in normal operating conditions in terms of continuity of supply and characteristics of voltage (symmetry, frequency, magnitude, waveform)<br>Note 1: Power quality expresses the user's satisfaction with the supply of electricity. Power quality is good if electricity supply is within statutory and any contractual limits, and there are no complaints from users, and vice-versa it is bad if the power supply is outside of limits and there are complaints from users.<br>Note 2: Power quality depends not only on the supply but can be strongly affected by the user's selection of equipment and installation practices. |
| 1999 | IEEE Std 1100-1999 IEEE Recommended Practice for Powering and Grounding Electronic Equipment | **power quality:** The concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring and other connected equipment. |
| 1999 | IEC Working Group 77A/WG09 | **power quality:** "Under consideration" |
| 2000 | IEC Working Group 77A/WG09 | **power quality:**<br>*Proposal # 1*: See quality of the supply *(See IEV definition below)*<br>*Proposal #2*: A set of technical parameters that describes the compatibility between electricity supplied on a network and the loads connected to that network. |
| 1987 | IEC 60050, 605-01-05 International Vocabulary (IEV) | **quality of supply:** An appraisal of the deviation of technical criteria outside a defined range (explicit or implicit) of the electricity supply or of the aggregate of electricity suppliers within an electrical system. |

**Table 2 — Power Quality names in French-speaking countries**

| Country | French Term | Literal English Translation |
|---|---|---|
| Belgium | 1. "Power Quality" | 1. No misgiving about using the English in a French phrase |
| | 2. Qualité de l'alimentation | 2. Quality of the (power) supply |
| Canada | 1. Qualité de l'onde | 1. Quality of the wave |
| France | 1. Qualité de la tension | 1. Quality of the voltage † |
| | 2. Qualité de la fourniture | 2. Quality of the supply |
| | 3. Qualité de l'énergie électrique | 3. Quality of the electrical energy |
| Switzerland | 1. Qualité de la fourniture | 1. Quality of the supply |
| | 2. Disponibilité de la fourniture ‡ | 2. Availability of the supply |

† Notwithstanding a current proposal within IEC terminology groups to change from "voltage" to "tension".
‡ In the context of UNIPEDE considerations.

## III. CONTENTS OF THE IEC DOCUMENT

### 1. Overview

From its inception, the IEC document was envisioned as consisting of two parts. The first part will be a normative standard defining the various parameters of power quality disturbances. These definitions will be in words as well as in precise mathematical formulae. The second part will be in the form of informative annexes providing important guidance on ***why***, ***where***, ***when,*** and ***how*** any power quality monitoring should be performed. One important aspect which needs to be recognized and is expected to surface in the final document, will be to address the measurement of ***currents*** (for harmonics and surges), a parameter presently ignored in typical power quality standards which have a limited focus on the ***voltage*** characteristics [10], [11], [12], [13].

*Normative Part* - The normative part of the document contains the following elements:

- The usual IEC recitation of scope, reference documents, and definitions;
- Organization of the measurements (instrument classes, parameters to be measured);
- Environment (accuracy tests, operating range);
- Measurement methods: power frequency, magnitude of the voltage, voltage dips and swells, interruptions, voltage unbalance, and mains signaling voltage;
- Technical characteristics: Two classes of instruments are described, with corresponding specifications of the environment and accuracy limits of each.

Some parameters are described in detail, others are referred to existing IEC standards, and some still at the *"Under Consideration"* stage. Referral is given to IEC standard 61000-4-15 for flicker, and to IEC standard 61000-4-7 for voltage harmonics and interharmonics but with no mention of harmonic currents. Some stakeholders are still focusing exclusively on voltage characteristics.

Left under consideration at this stage — but intended to be completed for the final project draft — several items still need consensus-building: power-frequency overvoltages, transient overvoltages (and currents) and, of all things, a definitive definition of the term "Power Quality."

***Informative Part*** -The informative part of the document contains the following elements:

- Measurements for contract applications;
- Trouble-shooting applications;
- Statistical surveys applications;
- Installation precautions;
- Transducers;
- Surge current vs. surge voltage;
- Bibliography.

This informative part will provide guidance on performing the measurements according to the specific purpose of the monitoring:

- Validating contractual compliance requires excellent repeatability and accuracy — one of the prime incentives in undertaking the work.
- Troubleshooting can be considerably facilitated by securing the "signatures" of disturbances. A signature may be difficult to describe in the quantitative terms used in contract language but is an extremely powerful tool for a diagnostic of a power quality problem.
- Surveys of power quality have been performed by many organizations, but comparisons have been difficult. The information and the recommendations provided on the subject in the corresponding annex should improve the situation for future surveys.
- Changing the emphasis of surge measurements from voltage to current will provide a more realistic and useful basis for the design and application of surge-protective devices [14].

### 2. Special considerations

Voltage measurements performed by digital instruments are essentially a long string of data, representing the values recorded during pre-determined time windows. To obtain useful summary results, these windows have to be aggregated over suitable time interval. The group has agreed on selecting three intervals:

- 10 or 12 cycles (for 50 Hz or 60 Hz, respectively)
- 10 minutes
- 2 hours

This aggregation process is then applied, depending on the needs, to the reporting of harmonics, interharmonics, unbalance and voltage magnitude.

## IV. SCHEDULE AND REMAINING WORK

To obtain an early feedback from the IEC National Committees, the somewhat unusual decision was made to circulate as a CD a document that still contains several important items left "Under Consideration." In this manner, it is expected that the next circulation of the document will be simpler and more efficient, with the working group taking advantage of the hiatus associated with the usual circulation of the document, comments, and responding to comments for working diligently on those items left "under consideration." It is expected that by the time of presentation of this paper, a second version CD will be completed and would be summarized in the oral presentation.

## V. ACKNOWLEDGMENTS

The IEC document described in this paper is the result of contributions from fifteen individual experts appointed by their National Committees, involving typically three meetings per year and substantial homework.

The seminal IEEE Standard 1159-1995 involved the contributions of 38 volunteers over a period of 8 years, and the group now working on the update includes more than forty volunteers.

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